Chapter 10: The C&SF Restudy

Agnes R. McLean, Eric Bush

Summary

Drainage works in south Florida to provide for flood control have resulted in the loss of roughly 6 million acre-feet of water storage, half of which came from Lake Okeechobee. In the urbanized lower east coast, approximately 2 million acre-feet of freshwater is now discharged directly to tide on an annual basis from canals and urban drainage systems, causing adverse impacts to coastal estuaries. While this drainage provides flood control, water lost to tide is not available for use during the dry season. The decrease in storage capacity of the south Florida and Everglades ecosystem has resulted in insufficient and improper timing of water deliveries to meet the needs of Everglades and Florida Bay restoration efforts, as well as the Caloosahatchee, St. Lucie and Lake Worth Lagoon estuaries, Biscayne Bay, urban areas and agriculture. The Comprehensive Review Study (Restudy) is reexamining the Central and Southern Florida (C&SF) Project to determine the feasibility of project modifications to improve the sustainability of south Florida.

Congress directed the United States Army Corps of Engineers (USACE) to comprehensively review the C&SF Project, with the expressed intent of determining if project modifications were desirable to achieve environmental enhancement and urban water supply and aquifer protection objectives in the area served by the project. The District acts as local sponsor of the project. An Integrated Feasibility Report and Programmatic Environmental Impact Statement (PEIS) detailing recommendations to achieve these objectives is to be submitted to Congress July 1, 1999. To meet this schedule, the multi-agency Restudy Team began the review of a number of alternative plans and scenarios for modifying the C&SF Project in September 1997. An initial draft plan was selected by the Restudy Team in June 1998; however, given the Restudy's schedule for public and agency review of the initial draft plan and the draft Feasibility Report/PEIS beginning in October 1998, a final Feasibility Report/PEIS will not be prepared until after January 1, 1999. Accordingly, the final details of the recommended plan for modifying the C&SF Project will not be known at the time that this Interim Report is submitted as required by the Act.

To select a plan, the Restudy Team formulated, evaluated, and compared alternative plans to existing (1995) and future (2050) without Base conditions. The 2050 Base is a projection of future hydrologic conditions in the study area without any of the Restudy components implemented. For planning and modeling purposes in the Restudy, the state's Everglades Program is assumed to be implemented in the 2050 Base condition. Construction of the Everglades Construction Project (ECP) as described in the February 15, 1994 conceptual design document and any supplemental treatment technologies necessary to achieve the numeric phosphorus criterion for the Everglades Protection Area (EPA) were included.

One of the main objectives of the Restudy is to create additional regional water storage to increase the volume and optimize the timing of water delivered to the EPA. This objective is consistent with the average annual increase of 28% to the protection area requirement contained in Section 373.4592(4)(b)2 of the Act. At the time this number was formulated, the operating premise was that "more was better," without emphasis on the timing of water deliveries. According to Dr. William Walker, the initial draft plan

resulted in a 19% increase in flow from the ECP to the EPA compared to the baseline period (1979-1988). This was an improvement over the projected 12% increase predicted for the 2050 Base condition (which was based upon a 31-year period of record). The 19% increase predicted for the initial draft plan is to be achieved concurrent with other measures to be undertaken to achieve optimal hydrologic conditions in the Everglades, such that there are additional inflows into the EPA along with those coming from the ECP. Restudy analyses have indicated significantly improved hydroperiods in the EPA with less than the 28% increase in inflow from the ECP.

The initial draft plan selected by the Restudy Team contains 50 components, or project features, formulated to meet study objectives. A summary description of plan components can be found in **Appendix 10-1**. **Table 10-1** depicts the performance of the initial draft plan as compared to the 2050 Base condition in a color format. “Green” represents success, a “yellow” designation represents uncertainty, and “red” is representative of not meeting study goals.

Table 10-1. Performance of the initial draft plan as compared to the 2050 Base Conditions (G = Successful, Y = uncertain, R = unsuccessful).

Subregion	2050*	Draft Plan*
LOSA	R	G
LECSA	R	G
Lake Okeechobee	Y	G
St Lucie Estuary	R	G
Caloosahatchee Estuary	R	G
Lake Worth Lagoon	Y	Y
Loxahatchee NWR	Y	G
Holey Land & Rotenberger	Y	G
WCA-2A	R	Y
WCA-2B		R
Northwestern WCA-3A		G
Northeastern WCA-3A		Y
Eastern WCA-3A		Y
Central & Southern WCA-3A		G/Y
WCA-3B		Y
Shark River Slough	R	G
Rockland Marl Marsh	R	Y
Biscayne Bay	Y	G
Florida Bay	R	G
Pennsuco		G
C-111 Basin	R	G
So Big Cypress	Y	G
SE Big Cypress	Y	G
Connectivity	Y	G
Sheet Flow	R	G
Fragmentation	R	G

* G = successful, Y = uncertain, R = unsuccessful

Introduction

The C&SF Project consists of a regional network of canals, levees, storage areas and water control structures. The project, first authorized by Congress in 1948, is a multipurpose water resources project. The authorized purposes of the project include flood control, regional water supply for agricultural and urban areas, prevention of salt water intrusion, water supply to Everglades National Park (Park), preservation of fish and wildlife, recreation and navigation. For close to 50 years, the C&SF Project has performed its authorized functions well. However, the project also has had unintended adverse effects on the unique natural environment that constitutes the Everglades and Florida Bay ecosystems (see **Chapters 3** and **2**).

Since passage of the Water Resources Development Act of 1986, planning for USACE projects is accomplished in two phases: the reconnaissance phase, which is conducted at full federal expense, and the feasibility phase, which is cost-shared between the USACE and the local sponsor, in this case, the District. The reconnaissance phase of the Restudy was initiated in June 1993, and the Reconnaissance Report was completed in November 1994. The feasibility phase of the Restudy was initiated in August 1995. In the feasibility study, a comprehensive plan for the overall C&SF system and the tools necessary to evaluate the comprehensive plan, as well as separable and incremental portions of the project, are being developed. Additionally, this feasibility phase includes findings from other ongoing study efforts including the Indian River Lagoon Feasibility Study and the Water Preserve Areas Feasibility Study. The end product of this feasibility study is a Feasibility Report with an integrated Programmatic Environmental Impact Statement (PEIS) that will serve as the basis for obtaining congressional authorization of the comprehensive plan.

Authorization of the C&SF Restudy

In 1992, Congress authorized a Comprehensive Review Study of the C&SF Project. The authorizing legislation, Section 309(1) of the Water Resources Development Act of 1992 (P.L. 102-580) states:

> "(1) CENTRAL AND SOUTHERN FLORIDA. – The Chief of Engineers shall review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643; 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."

The study is also authorized by two resolutions of the Committee on Public Works and Transportation, U.S. House of Representatives, dated September 24, 1992. The first resolution states:

> "Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, 80th Congress, 2nd Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes."

The second resolution states:

> "Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, 80th Congress, 2nd Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes for Florida Bay, including a

> comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem."

The Water Resources Development Act of 1996 was enacted on October 12, 1996. Section 528 provides direction and guidance to the Restudy. Specifically, the Secretary of the Army is directed to develop:

> "…a proposed comprehensive plan for the purpose of restoring, preserving and protecting the south Florida ecosystem. The comprehensive plan shall provide for the protection of water quality in, and the reduction of the loss of freshwater from, the Everglades. The comprehensive plan shall also provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project."

The Secretary of the Army is further directed to complete the feasibility phase of the Restudy by July 1, 1999, and submit to Congress the comprehensive plan consisting of a Feasibility Report and a PEIS covering the proposed federal action set forth in the plan. The Act also establishes a 50-50 cost-share for C&SF Project modifications, including water quality features essential for restoration, and authorizes construction of critical restoration projects.

Purpose, Coverage and Scope of the C&SF Restudy

The purpose of the Restudy is to reexamine the C&SF Project to determine the feasibility of structural or operational modifications to the project essential to the restoration of the Everglades and Florida Bay ecosystems, while providing for other water-related needs such as urban and agricultural water supply and flood control in those areas served by the project. The intent of the study is to evaluate conditions within the study area, make recommendations to modify the project to restore important functions and values of the Everglades and Florida Bay ecosystems, and plan for the water resources needs of the people of south Florida for the next 50 years.

The feasibility study includes hydrological modeling, ecological modeling, water quality analyses, and water supply studies that refine and augment the information developed in the reconnaissance phase of the Restudy. The study effort identifies the most suitable and beneficial plan components for south Florida ecosystem restoration and urban and agricultural water supply, as well as how the components should be incrementally implemented for maximum benefit consistent with a cost-effective incremental analysis. The Feasibility Report will identify a comprehensive plan for the C&SF Project and an adaptive Everglades restoration implementation and operational strategy based on monitoring, evaluation and modeling.

The C&SF Project Restudy includes all of the C&SF Project area with the exception of the Upper St. Johns River Basin. The area encompasses approximately 18,000 square miles from Orlando to Florida Bay. Major areas include the Kissimmee River, Lake Okeechobee, St. Lucie and Caloosahatchee basins, Everglades Agricultural Area (EAA), Water Conservation Areas (WCAs), Upper and Lower East Coast, Lower West Coast, the Park, Big Cypress National Preserve and Florida and Biscayne bays. As such, the study area includes all of the EPA. The Kissimmee River, Lake Okeechobee and the Everglades are the dominant watersheds that connect a mosaic of wetlands, uplands and coastal and estuarine areas.

Characteristics of the Pre-project South Florida Ecosystem

The pre-project wetlands of southern Florida covered an area estimated at 8.9 million acres. This region was a complex system of hydrologically interrelated landscapes, including expansive areas of sawgrass sloughs, wet prairies, cypress swamps, mangrove swamps, and coastal lagoons and bays. Prior to man-made drainage works, the characteristics of this network of wetland landscapes could be described by a set of physical and ecological features that were present at a regional scale, which gave definition and function to these ecosystems. It was the defining physical characteristics of this region that provided the spatial and temporal framework necessary for the functions and values of these unique wetlands.

Dynamic storage was the mechanism by which hydroperiods and water depths were maintained throughout the freshwater Everglades, both seasonally and interannually. The physiographic structure contributing to dynamic storage included a very shallow elevation gradient from Lake Okeechobee to Florida Bay, vast expanses of emergent vegetation, thick peat substrates, sand hills and highly permeable limestones. Water flowing over land (known as sheetflow) moved steadily southward; however, it moves so slowly that, in effect, water was banked during one season to use in another. Transport times varied between these structural elements from months to years.

Throughout the system, ground water seepage (driven by hydraulic gradients) provided the base flow of creeks, rivers and (possibly) surface runoff across the mangrove zone. The extended hydroperiods of the natural system depended more on the large dynamic storage capacity and delayed flow-through (the natural hydrologic features of the region) than on the immediate effects of rainfall. Due to dynamic storage and the slow rate of water flow throughout the natural system, wet season rainfall kept the wetlands flooded and maintained freshwater flow to the estuaries well into the dry season. The carry-over effect was so great that a year of high rainfall maintained surface water in wetlands and freshwater flow to estuaries into one or more subsequent drought years. This extended storage capability made wetlands and estuaries less vulnerable to south Florida's spatially and temporally variable rainfall.

The vastness of the pre-project wetland extent made it possible for the natural ecosystem to: 1) support genetically viable numbers and subpopulations of species with large feeding ranges or narrow habitat requirements, 2) provide the aquatic production to support large numbers of higher vertebrates in a naturally nutrient-poor environment, and 3) sustain habitat diversity due to natural disturbance. In the pre-project era, nutrients that were the basis of primary production were derived principally from rainfall for the core portion of the Everglades ecosystem. Sheetflow enhanced the uptake of nutrients by vegetation and soils from the water column. The periphyton community, an assemblage made up of microscopic algae, microbes and small grazing animals, not only assimilated available nutrients from the water column, but also created an environment that precipitated phosphorus, in association with abundant calcium carbonate. The system was extremely oligotrophic (nutrient-poor), given that nutrient loads were spread over the entire areal extent. During seasonal dry-downs, topographic depressions (e.g., alligator holes) became areas of concentrated aquatic biomass, producing localized feeding opportunities for large carnivores, including wading birds. Higher vegetation as well as periphyton were adapted for surviving under low-nutrient conditions.

Habitat heterogeneity maintained by microtopographic features, small-scale climatic variation and natural disturbances (such as freezes, fires and storms acting on the large spatial scale of the wetlands) was a major contributor to biotic diversity and the persistence of populations. The mosaic of habitat types and water depths provided the spatial framework for the production and survival of animals under a wide seasonal and annual range of hydrologic conditions.

The vegetative landscape resulting from this vast, low-relief, low-gradient landform was a diverse mosaic of plant communities. These communities varied in extent from patches of tens of meters to areas approaching physiographic provinces. The larger expanses had more long-term resiliency than the patches. Large spaces were necessary to maintain resiliency under conditions that changed on scales from seasons to decades. To some extent, when maps from the 1800s are compared with maps of the 1980s. They reveal large- scale persistence of landscape patterns, even in the face of major anthropogenic disturbance.

History of the C&SF Project

In the late 1800s and early 1900s, the primary obstacle to settlement and development in south Florida was flooding. The state had significant natural resources that were subject to long periods of inundation. Flood control works were necessary to realize the economic potential of these resources. As a result, major drainage projects were initiated that were sponsored by the state of Florida. There were problems associated with many of these projects, and following a series of hurricanes and tremendous loss of life, the state initiated a partnership with the federal government (through the USACE) to address flooding and other problems. As this partnership continued to work toward controlling the hydrologic conditions that were hampering economic development, project planners recognized a need to strike a balance among competing economic needs. The emphasis on economic goals clearly focused the design of the C&SF Project toward the economic development of the region, with little understanding of or concern for the consequences to the natural system.

In 1948 a comprehensive plan was presented in a report to Congress (80^{th} Congress, 2^{nd} Session, House Document 643) to meet a set of objectives with the ultimate goal of economic development. These objectives included: reducing flood damages and enhancing land use throughout the region; controlling ground water levels for agriculture; storing excess flood water for beneficial use; reducing salt water intrusion into coastal wellfields; preserving fish and wildlife; enhancing navigation through a cross-Florida waterway; and providing recreational opportunities. While the project as presently constructed has met and surpassed many of these objectives, it has also had unintended adverse environmental consequences. These consequences have driven the need for the Restudy.

To meet the project objectives, the C&SF Project sacrificed a significant portion of the central and south Florida ecosystem. The Kissimmee River Basin was channelized. Lake Okeechobee was diked to prevent uncontrolled discharges from the lake. The region of the Everglades, now called the EAA, was drained, and ground water levels managed to reduce flood damages to agricultural production. The flooding risk was also reduced in the lower east coast to allow for urban and suburban development and intensified agriculture. Central portions of the Everglades were diked to create the WCAs, areas in which water could be stored for human needs in the lower east coast and for deliveries to the Park. While some fish and wildlife value was expected to remain in the WCAs, the only natural area intended for preservation in pristine condition was the Park.

Effect of the C&SF Project on the Natural System

The defining characteristics of the pre-project ecosystem have either been lost or substantially altered, as a result of land use and water management practices during the past 100 years in south Florida. Loss in spatial extent of natural areas has been most severe in the past 50 years with the construction of the C&SF Project; nearly half of the original Everglades ecosystem has been converted to agricultural and urban uses. The ecological effects of this loss in spatial extent include: 1) a substantial reduction in habitat options for wildlife, 2) reduction in the system-wide levels of primary and secondary production, and 3) changes in the proportions of community types within the remaining system. The hydrology of the remaining Everglades has become substantially altered by the operation of the C&SF Project, which has: 1) reduced average annual flows and surface water stages, 2) lowered regional ground water, 3) either increased or decreased annual hydroperiods, depending on location, 4) geographically relocated long- and short-hydroperiod wetlands, 5) reduced the extent of long-hydroperiod refugia, 6) altered the frequency, duration and magnitude of interannual wet and dry cycles, and 7) raised average salinity levels in estuaries. Overall, the construction and operation of the C&SF Project and its subsequent modification of the natural system have: 1) contributed to the substantial reduction in spatial extent and system resiliency, 2) provided a network of canals and levees that have accelerated the spread of polluted water and exotic species, 3) greatly reduced the water storage capacity within the remaining natural system, and 4) created an unnatural mosaic of impounded and over-drained marshes throughout the natural system.

The lack of storage in the system, particularly during wet periods, has led to ecological damage of Lake Okeechobee's littoral zone and damaging regulatory releases to the east-west estuaries. Conversely, in dry periods, this lack of storage has led to water supply shortages for both the human and natural environment. The Governor's Commission for a Sustainable South Florida stated in its October 1995 Initial Report that, "South Florida is not sustainable on its present course."

The Restudy Planning Process

The purpose of the Restudy is to review how well the C&SF Project is functioning and determine what modifications may be needed to achieve a new set of objectives. The precursor to the feasibility phase (the reconnaissance study) identified a set of regional-scale planning objectives. The Governor's Commission for a Sustainable South Florida also developed a set of regional-scale objectives for the Restudy. A synthesis of these resulted in an inclusive set of objectives to achieve two general goals for the south Florida ecosystem: 1) enhance ecologic values, and 2) enhance economic values and social well-being.

Goals and Objectives for the C&SF Restudy

Major goals and subordinate objectives for the Restudy have been established to enhance ecological values, economic values, and social well being. The goals to enhance ecologic values include: increase the total spatial extent of natural areas; improve habitat and functional quality; and improve native plant and animal species abundance and diversity. The goals to enhance economic values and social well-being include: improve availability of freshwater (agricultural/municipal & industrial); reduce flood damages (agricultural/urban); provide recreational and navigational opportunities; and protect cultural and archeological resources and values.

The Restudy planning objectives were developed as the result of public participation and scientific knowledge of south Florida. Through workshops conducted during the reconnaissance phase of the Restudy and subsequent technical evaluations, it is evident that the C&SF Project must continue to provide for project purposes, as originally intended. Therefore, many of the economic and social objectives are similar to those of the original C&SF Project. Unlike the original set of objectives for the C&SF Project, however, the Restudy includes objectives that recognize the importance of the natural system, both for its value as an ecosystem, and for its support role for the social structure of south Florida.

Public input into the Restudy is being received in several ways. Two rounds of public focus-group meetings were held January through May, and September through December 1997. Monthly briefings are given to the Governor's Commission for a Sustainable South Florida and the Governing Board of the District. These meetings also allow for public comment. A series of technical workshops were held with the District's three advisory committees (agricultural, utility and environmental) to answer detailed questions concerning the methodologies employed in the Restudy; briefings were given to the individual committees as well. Formal public hearings, to coincide with the release of the draft Feasibility Report, are scheduled for November 1998. Additionally, public comments on the Restudy are received via the internet, from the Restudy web site at www.restudy.org.

The Restudy is being accomplished by an interdisciplinary, multi-agency team. The team includes biologists, ecologists, economists, engineers, Geographic Information Systems specialists, hydrologists, planners, public involvement specialists and real estate specialists from a number of federal, state, tribal and local government agencies.

The Existing and Future Without Project Conditions

Information from a variety of sources, both physical and socioeconomic, is used in the planning effort to define relevant conditions in south Florida under various scenarios. The differences among the conditions are evaluated and compared and provide a major basis for plan selection. Conditions that exist at the time of the Restudy are called the Existing Condition. In the Restudy, the term **"1995 Base"** has been chosen to reflect this condition. The **Existing Condition** represents typical operations and facilities in recent years rather than precise data for the year of the study. The Existing Condition reasonably represents the relevant, current study area conditions. The **Future Without Project Condition** describes the

condition that is expected to occur if no action is taken and is synonymous with the no action alternative. In the Restudy, this condition is termed the **"2050 Base."** The Without Project Condition makes it possible to describe what society will have to give up, if the chosen scenario is the no action plan.

Informational criteria used to determine the existing and future without project conditions for the C&SF Restudy include:

- Climate
- Sea level
- Population and socio-economic conditions
- Land use
- Natural area land cover (vegetation)
- Municipal & industrial and agricultural water demands
- Region-wide water management and related operations
- Physical facilities & operations – Lake Okeechobee & Lake Okeechobee Service Area
- Physical facilities & operations – WCAs
- Physical facilities & operations – the Park
- Physical facilities & operations – Lower East Coast Service Area
- Physical facilities & operations – Western Basins and Big Cypress

The Future Without Project Condition includes such ongoing restoration projects as the Kissimmee River, Modified Water Deliveries to the Park, C-111 Project, and the Everglades Program, as described in the Everglades Forever Act. A summary table of the Existing Condition and Future Without Project Condition scenarios can be found in **Appendix 10-2**.

Formulation and Evaluation of Alternative Project Plans

Plan formulation is an iterative planning process that identifies alternative plans to achieve a set of planning objectives, and allows those plans to be modified as more information becomes available. Every iteration provides an opportunity to refine and sharpen the planning focus. The reconnaissance phase of the Restudy and the Lower East Coast Regional Water Supply Plan process provided a foundation upon which the feasibility study was able to build.

Alternative plans were formulated for the Restudy that could be evaluated to determine progress toward meeting planning objectives as well as other effects. Numerous studies support the theory that the remaining natural system can be changed in the direction of its pre-project wetland character, through modifications to the hydrologic features. The main issue of the study is how to accomplish the ecologic restoration objectives while allowing the system to serve the economic and social needs of the region.

Strategic hydrologic objectives provide a basis for formulating alternative plans and measuring effectiveness of both ecologic and economic goals. These objectives include:

- Regaining lost storage capacity.
- Restoring more natural hydropatterns.
- Improving timing and quantities of freshwater deliveries to estuaries and
- Restoring water quality conditions.

From September 1997 through June 1998 alternative comprehensive plans were formulated and evaluated. Each plan was judged on how well it would meet study goals and performance targets compared to 1995 and 2050. Hydrologic models (discussed below) were run for each alternative plan to produce performance measure outputs unique to that plan. Other evaluation tools such as ecologic and water quality models were also run and their output evaluated. This iterative formulation and evaluation process was the basis by which the initial draft plan was identified in June 1998.

Alternative Development and Evaluation Methodology

The goal of the comprehensive plan hydrologic alternative evaluation and development process was to develop alternative plans to meet the planning objectives established for the Restudy. Alternatives were developed from a process that began with a starting configuration and methodically created new alternatives based upon an evaluation against hydrologic and ecologic performance measures. Descriptions of the performance measures can be found on the Restudy web site (www.restudy.org). The Restudy team employed a two-phase approach to accomplish the iterative evaluation/development of alternative comprehensive plans.

Within the Restudy team, two task teams were organized – the Alternative Evaluation Team and the Alternative Development Team. The Alternative Evaluation Team evaluated the performance of each alternative and provided input to the Alternative Development Team about how the alternative performed and offered strategies for the development of the next alternatives. The Alternative Development Team then took this information and worked to develop the next alternative plan to improve performance in meeting performance measure targets and planning objectives.

Following seven iterative cycles of alternative plan formulation evaluation and development, more detailed evaluations were undertaken by the Restudy team. These evaluations included assessments of alternative plan impacts on specific resources such as threatened and endangered species, economic, social and cultural resources, flood control and costs. Based upon this work, an initial draft plan was developed.

Computer Modeling Tools Supporting the Restudy

Computer models are designed to enhance planners' ability to predict how the south Florida ecosystem will react under different scenarios in the Restudy and to assist decision-making regarding the selection of alternative draft plans. The primary hydrologic tools that enabled the Restudy team to evaluate alternative plans were the South Florida Water Management Model (SFWMM) v3.4 and the Natural Systems Model (NSM) v4.5, both developed primarily by the District.

The SFWMM v3.4 is a regional-scale computer model that simulates the hydrology and management of the water resources system from Lake Okeechobee to Florida Bay. The model covers an area of 7,600 square miles using a grid of two-mile by two-mile cells, and includes inflows into Lake Okeechobee from the Kissimmee River, as well as runoff and demands in the Caloosahatchee River and St. Lucie Canal basins. The SFWMM simulates the major components of the south Florida hydrologic cycle, including rainfall, evapotranspiration, infiltration, overland and ground water flow, canal flow, canal ground water seepage, levee seepage and ground water pumping. The model simulates hydrology on a daily basis using climatic data from 1965 to 1995. The NSM is basically the SFWMM with structures and canals removed (see **Chapter 2**). The NSM v4.5 provides a comprehensive pre-drainage hydrologic description of south Florida including pre-drainage topographic and geographic estimates. As with the SFWMM, the NSM uses a 31-year period of record (1965 to 1995) hydro-meteorological data and predicts how water would have moved through the pre-project system.

Two water quality models developed by the District were used in alternative plan evaluation, the Lake Okeechobee Water Quality Model (LOWQM) and the Everglades Water Quality Model (EWQM). The LOWQM simulates eutrophication processes in both the water column and underlying sediments in Lake Okeechobee. The model framework includes the oxygen cycle, phosphorus cycle and nitrogen cycle; three algal groups representing green algae, diatoms and cyanobacteria; suspended solids; and processes related to sediment resuspension, the silica cycle and nitrogen fixation. External forcing functions that drive the model include solar radiation, temperature, wind-induced sediment resuspension, surface discharges in and out of the lake, rainfall, evaporation and nutrient loads. The EWQM is a tool that evaluates phosphorus movement and concentration over the EPA based on hydrologic and phosphorus loads, phosphorus settling rates, atmospheric phosphorus depositions, as well as ground water interactions. The model is used to assess the effect of phosphorus distribution in the EPA due to best management practices, stormwater treatment areas and other Everglades construction projects that result in changes of the amount, timing and location of hydrologic and phosphorus loads into the EPA. The EWQM is described in greater detail in **Chapter 3** of this report.

One ecologic model was employed by the Restudy team to evaluate alternative plans. The Across Trophic Level System Simulation (ATLSS) was developed by the U.S. Geological Survey (USGS) and University of Tennessee. ATLSS integrates several different trophic levels of the system and includes process models for lower trophic levels; structured population models for functional groups of fish, macroinvertebrates, amphibians and reptiles; and individual-based models for consumers. ATLSS is integrated across the freshwater landscape of south Florida and involves spatial scales of resolution as small as 28 meters. It is particularly valuable in analyzing the effects of landscape alternatives on endangered species or those of special concern.

Water Budget Comparisons Between the 1995 Base, 2050 Base, and the Initial Draft Plan

In order to understand primary water budget data and performance relative to performance measures, water budget maps were developed that depict the movement and volumes of water flow for the 1995 Base, 2050 Base, and the Initial Draft Plan. The maps (see **Figures 10-1, 10-2,** and **10-3**) are in units of 1,000 acre feet and represent annual means over the 31-year simulation period. What follows is a brief description of selected elements of the water budget data found on the maps. It should be noted that the description below denotes selected regional water deliveries to the area served by the C&SF Project. Rainfall and other data are found on the maps themselves. Some significant sources of water supply, such as reservoirs in the Lower East Coast, are not shown or quantified on the maps, yet provide an important means of achieving performance measure goals. For a description of historical aspects of south Florida hydrology, see **Chapter 2** of this Report.

In the 1995 Base, The EAA receives 377,000 acre feet of water for agricultural water supply, the Caloosahatchee Basin 71,000 acre feet, and the St. Lucie Basin receives 23,000 acre feet. The Lower East Coast receives 187,000 acre feet in the 1995 Base for both urban and agricultural water supply. In the 2050 Base, the EAA receives 329,000 acre feet of water, the Caloosahatchee Basin 90,000 acre feet, and the St. Lucie Basin 19,000 acre feet. The Lower East Coast receives 252,000 acre feet. In the Initial Draft Plan, the EAA receives 321,000 acre feet from two sources (Lake Okeechobee and the EAA reservoir), the Caloosahatchee Basin 81,000 acre feet (from the lake and Caloosahatchee reservoir), and the St. Lucie Basin 26,000 acre feet (from the lake and St. Lucie reservoir). The Lower East Coast receives 320,000 acre feet of water (including water from Lake Okeechobee, the WCAs, the L-8 reservoir and ASR, but not including east coast reservoirs).

In the 1995 Base, environmental releases (BMP Replacement Water) to the WCAs total 165,000 acre feet and flood control releases equal 62,000 acre feet. Environmental water deliveries to both the Caloosahatchee and St. Lucie estuaries are zero while flood control discharges are 290,000 and 126,000 acre feet respectively. Environmental deliveries to the Park are 428,000 acre feet and flood control discharges are 421,000 acre feet. In the 2050 Base, environmental releases to the conservation areas are 165,000 acre feet with flood control discharges of 111,000 acre feet. Environmental water deliveries to the Caloosahatchee and St. Lucie estuaries remain at zero, while flood control discharges are 206,000 and 88,000 acre feet respectively. Environmental water deliveries to the Park are 544,000 acre feet and flood control discharges are 602,000 acre feet. In the Initial Draft Plan, the WCAs receive 427,000 acre feet of environmental deliveries and 102,000 acre feet of flood discharges. The Caloosahatchee Estuary receives 428,000 acre feet in environmental deliveries and 19,000 acre feet in flood control discharges. The St. Lucie Estuary receives 54,000 acre feet in environmental deliveries and 13,000 acre feet in flood control discharges. The Park receives 1,495,000 acre feet in environmental deliveries and no flood control discharges.

Environmental deliveries of water are a result of a change in operations, made possible by the various methods of storing water in the Initial Draft Plan. These operational changes are triggered by rainfall-driven schedules and estuary targets that improve volumes and timing of such releases over what is being delivered today.

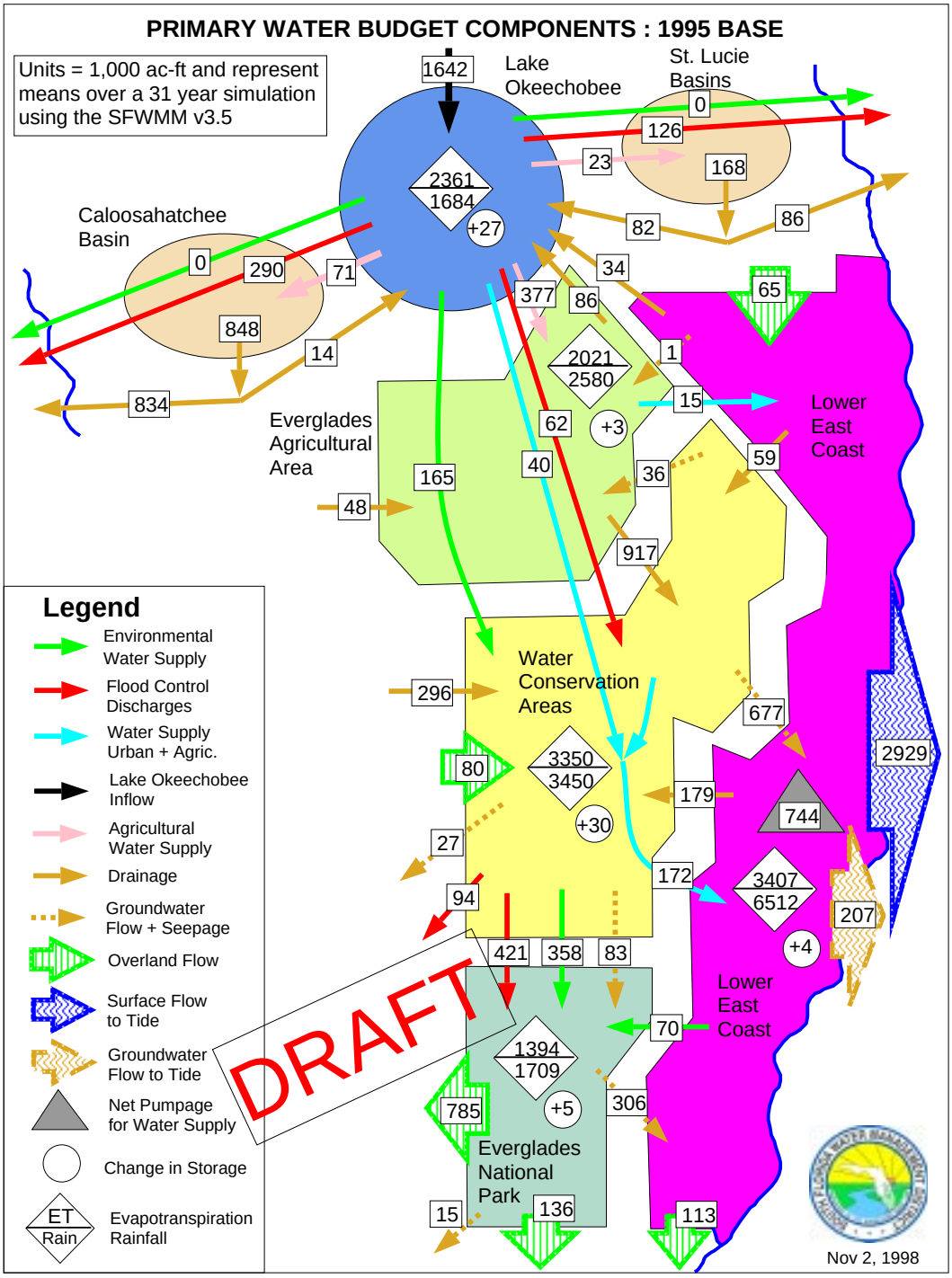

Figure 10-1. Primary water budget components: 1995 Base. This figure was produced through simulations by the Restudy modeling team and will be included within the final version of the Central and South Florida Comprehensive Review Study.

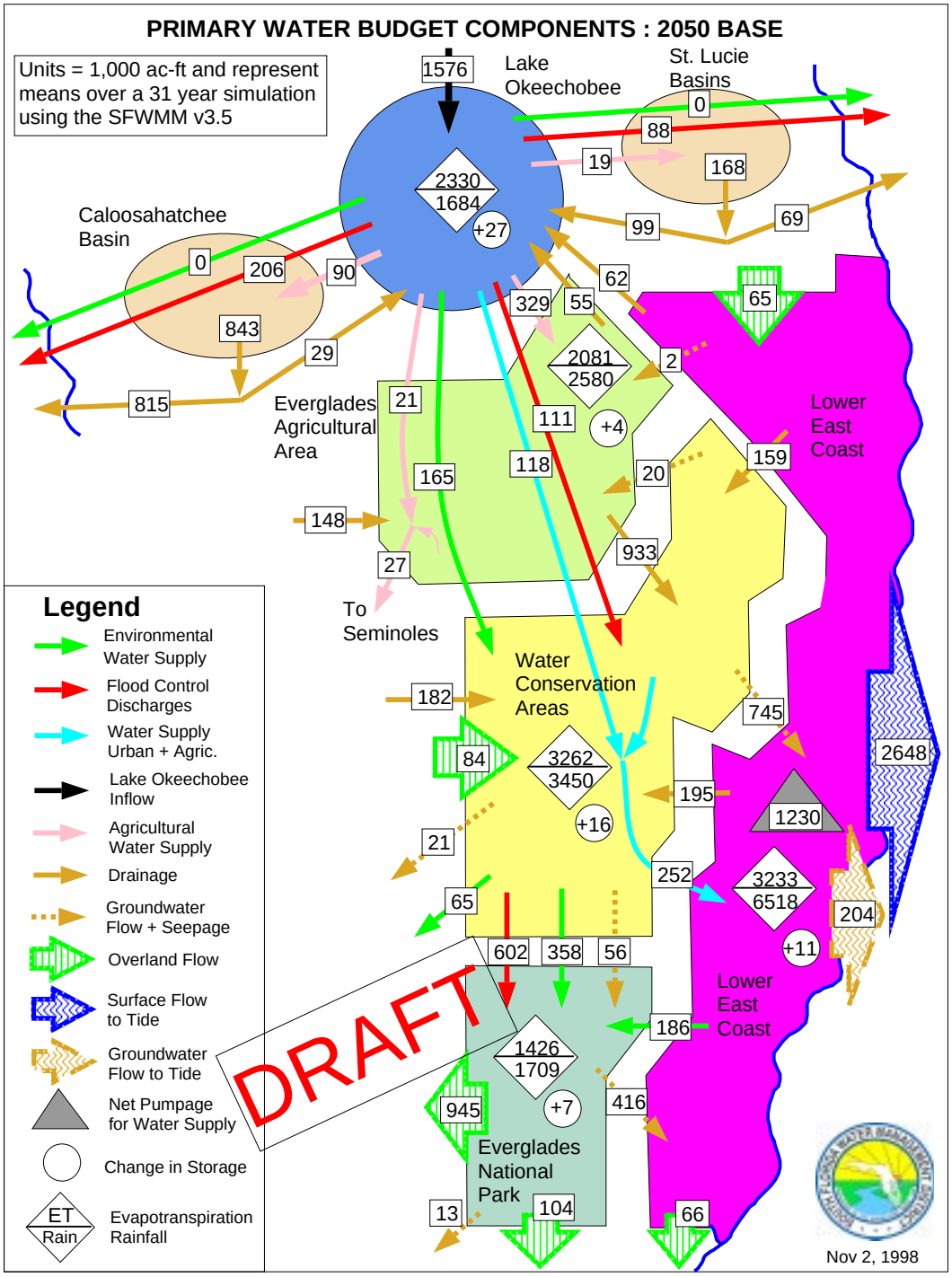

Figure 10-2. Primary water budget components: 2050 Base. This figure was produced through simulations by the Restudy modeling team and will be included within the final version of the Central and South Florida Comprehensive Review Study.

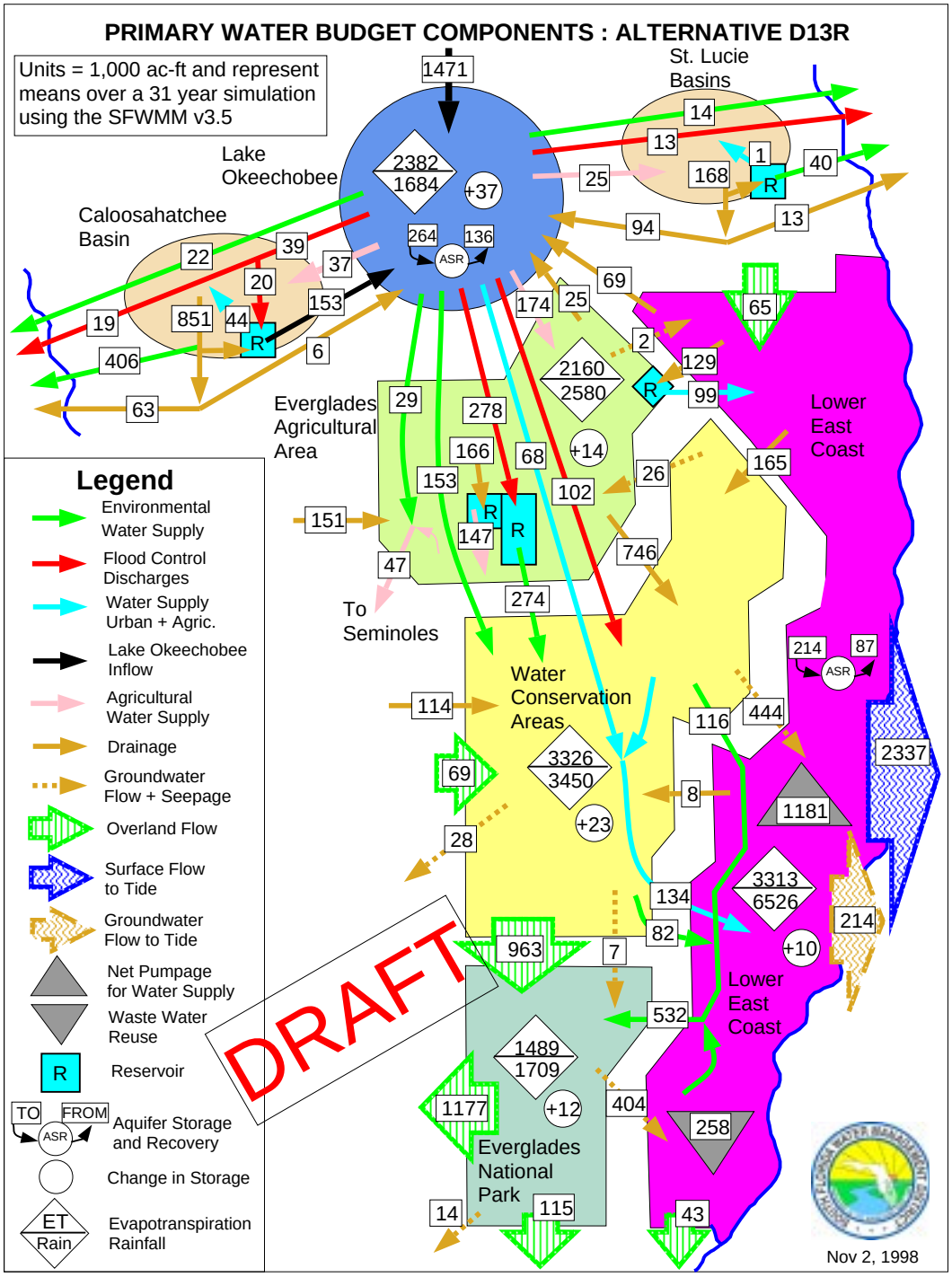

Figure 10-3. Primary water budget components: Alternative D13R. This figure was produced through simulations by the Restudy modeling team and will be included within the final version of the Central and South Florida Comprehensive Review Study.

Cost Figures for Planning and Initial Draft Plan

The feasibility study begins with the execution of the Feasibility Cost-Sharing Agreement and concludes with the issuance of the Division Engineer's Public Notice by the USACE. The District, as local sponsor, agreed to cost-share in the study with the USACE and has provided both cash and in-kind services. The total estimated cost of the study is $19.9 million. All study tasks were organized in a code of accounts, which can be found in **Appendix 10-3**.

The feasibility report for the C&SF Project will consist of proposed structural and operational changes to the existing project. Individual project changes, or features, are termed components. Due to the size and complexity of the overall effort, it is recognized that the separate components cannot be implemented simultaneously. The report will provide a framework for integrating geographically separate components into a holistic solution and a strategy for implementation. A summary description of plan components for the initial draft plan can be found in **Appendix 10-1**. The working cost estimate for the Recommended Plan for the Restudy, which includes the Initial Draft Plan plus 11 other project elements (elements that were not able to modeled using the SFWMM), is $7.8 billion.

Linkages Between the Restudy and the ECP

The Act set into action a plan for restoring a significant portion of the remaining Everglades ecosystem through a program of construction projects, research and regulation. The feasibility report for the C&SF Restudy will identify long-range options that further the ecosystem restoration objectives of the Act while continuing to provide for other authorized water resource-related needs.

Congress directed the USACE to comprehensively review the C&SF Project, with the expressed intent of determining if project modifications were desirable to achieve environmental enhancement and urban water supply and aquifer protection objectives in the area served by the project. As stated previously, an initial draft plan was selected by the team in June 1998; however, given the Restudy's schedule for public and agency review of the initial draft plan and the draft Feasibility Report/PEIS beginning in October 1998, a final Feasibility Report/PEIS will not be prepared until after January 1, 1999. Accordingly, the final details of proposed modifications to the C&SF Project resulting from the feasibility phase of the Restudy will not be known at the time that this report is submitted, as required by the Act.

One of the evaluations conducted during the plan formulation and evaluation phase of the Restudy was the effect of hydrologic changes resulting from implementation of alternative plans under consideration on the ECP. This evaluation was conducted by William W. Walker, Jr. for the USACE and the Department of the Interior (Walker, 1998). Walker's evaluation utilized output from the SFWMM for both the 1965-1995 period of record, which was used by the Restudy Team to evaluate hydrologic effects of Restudy alternatives, and the 1979-1988 baseline period on which the design of the ECP is based. Consistent with other Restudy evaluations, the alternative plans were compared to existing (1995) and future (2050) Base conditions. The 2050 Base is a projection of future hydrologic conditions within the District (as depicted by the SFWMM) without any Restudy components implemented. For planning and

modeling purposes in the Restudy, the State's Everglades Program, including the construction of the ECP as described in the February 15, 1994 conceptual design document (Burns and McDonnell, 1994) and any supplemental treatment technologies necessary to achieve the numeric phosphorus criterion for the EPA, are assumed to be fully implemented in the 2050 Base condition.

Walker's evaluation indicates that the 2050 Base condition and Restudy alternatives, if implemented, may cause potential performance problems in the ECP. This was true for both the 1965-1995 and 1979-1988 periods of record. The projected performance problems are due to increases in hydraulic and phosphorus loads to the STAs compared to the design for the ECP. Using the interim concentration target of 50 ppb as a measure of projected performance, average phosphorus concentrations in outflows from the STAs are predicted to increase slightly under 2050 Base conditions. However, it should be noted that all of the Restudy alternative plans resulted in improved overall performance of the STAs compared to projected future base conditions. Performance of STA 3/4 was projected to be significantly improved compared to 2050 Base conditions due to the inclusion of a 60,000 acre reservoir in the EAA in the Miami Canal/North New River Canal basin. It should be noted that the Restudy will identify any modifications to existing ECP design or operations necessary to ensure that their performance will not be adversely impacted by the implementation of Restudy components.

One of the main objectives of the Restudy is to create additional regional water storage to increase the volume and optimize the timing of water delivered to the EPA. This objective is consistent with the average annual increase of 28% to the protection area requirement contained in Section 373.4592(4)(b)2 of the Act. At the time this number was formulated, the operating premise was that "more was better," without emphasis on the timing of water deliveries. According to Walker, the initial draft plan resulted in a 19% increase in flow from the ECP to the protection area compared to the baseline period (1979-1988). This was an improvement over the projected 12% increase predicted for the 2050 Base condition (which was based upon a 31-year period of record). The 19% increase predicted for the initial draft plan is to be achieved concurrent with other measures undertaken to achieve optimal hydrologic conditions in the Everglades, such that there are additional inflows into the protection area along with those coming from the ECP. Restudy analyses have indicated significantly improved hydroperiods in the WCAs and the Park with less than the 28% increase in inflow from the ECP.

The feasibility report for modifying the C&SF Project resulting from the Restudy will identify options (water resources construction projects, operational changes) that are fully consistent with and will further the ecosystem restoration purposes of the Act, while continuing to provide for the other authorized purposes of the C&SF Project. There are several important preliminary conclusions that can be drawn from the Restudy Team's evaluation of the effect of the 2050 Base condition and the initial draft plan on the ECP:

- The Restudy will identify any modifications of the existing ECP design/operations necessary to ensure that their performance will not be adversely affected by subsequent implementation of Restudy components.
- Implementation of the initial draft plan is projected to improve the overall performance of the ECP, particularly STA 3/4.
- Supplemental technologies investigations and future design work should be based on a period of record more representative of actual hydrologic conditions (e.g., 1965-1995); Although the 1991 Settlement Agreement mandates that the design of STA 3/4 be based on the 1979-1988

period of record, the availability of the longer 1965-1995 period of record used by the Restudy is more representative of actual hydrologic conditions and should be used in STA 3/4 design.

- Future design of STA 3/4 should include a consideration of the Restudy's recommended plan, including specifically the reservoir to be located in the Miami Canal/North New River Canal basin within the EAA, a modified regulation schedule for Lake Okeechobee, and rain-driven operations in the EPA.

It should be noted that the Restudy is much more comprehensive in geographic scope than the Everglades Construction Program, as described in the Act. The Restudy is evaluating environmental and water supply conditions as affected by the C&SF Project in the Kissimmee River Valley, Lake Okeechobee, the St. Lucie and Caloosahatchee River systems, the Lower East Coast, Big Cypress National Preserve, and Florida Bay, in addition to the EPA. See **Chapter 12** for additional discussion of the Everglades Program and linkages between the ECP and other restoration components.

Findings on the Comprehensive C&SF Restudy

- The Restudy is an interagency effort with a large geographic scale (18,000 sq.mi.) and a 2050 planning timeframe. This level of effort is essential to restore the regional hydrologic system of south Florida.
- The C&SF Restudy will provide a plan for regional storage and movement of water to restore and sustain the Everglades Protection Area.
- The current planning level cost estimate for implementation of the Restudy is $7.8 billion, and a recommended plan for a sustainable Everglades ecosystem is scheduled to be delivered to Congress in July, 1999.